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50. Internationales Wissenschaftliches Kolloquium
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Sub-micron structures for nanolitre flow-cells

ABSTRACT

Fluidic structures with characteristic dimensions in the range of microns and total volumes of only a few nanolitres provide the possibility to analyse fundamental effects which appear in the area of classic to nano scale fluidics. A better understanding of molecular processes in micro- and nano-fluidics will reduce the amount of analytes needed in such structures and will lead to new methods for biological and chemical applications [1].

FABRICATION METHODS

The production of micro flow-cells requires high accuracy of micro-techniques for structuring as well as for packaging. For sustainable results in micro- and submicro-fluidics it is necessary to examine many different channel designs, that all need to have the same quality of the channel wall surface and the accuracy of the structure dimensions. The flow-cells used during the experiments consist of a structured poly-methylmethacrylate (PMMA) layer which is covered with unstructured PMMA. These layers are usually applied onto either silicon or glass substrates. In early experimental stages the realisation is tested with structured PMMA substrates. For structuring PMMA layers of a few microns, UVC-lithography, X-ray and E-beam lithography, or one of those methods followed by and hot embossing are used in order to create fluidic devices with lateral dimensions down to a few hundred nanometres. The quality and cost of the PMMA flow-cells is determined by the structuring technique chosen.

<u>E-beam lithography:</u> The pattern is directly written into the PMMA-substrate using an E-beam and afterwards wet processed. The structure details made with this serial technique can be as small as approximately one hundred nanometres. This rapid method produces high quality structures but also has a high cost per piece.
<u>UVC-lithography:</u> PMMA is exposed to UVC through an e-beam generated chromium mask and the modified areas are chemically dissolved. This technique allows structures in the range of 800 nm. For parallel production of several dozen structures this method leads to a moderate cost per piece.

X-ray lithography: This technique is similar to UVC-lithography with a parallel 1:1 copy, but instead of UV-light, a parallel X-ray source is used, as well as different mask materials. It enables the mapping of structure details within a few hundred nanometres and can create structures with higher aspect ratio than with e-beam lithography. Due to the x-ray absorber mask this method requires more time, but it also achieves the highest quality.

Hot embossing: A metallic moulding tool with a negative complement of the actual fluidic structures is pressed into heated PMMA. The hot embossing process is a parallel replication method developed for series production and is therefore suitable if higher quantities of fluidic devices are needed. The moulding tool can be made by electroplating PMMA-structures which are patterned by one of the named techniques. With the fabrication of several hundred flow-cells, the cost per piece is low, and the quality is nearly as good as with the lithographic methods.

EXPERIMENTAL

Several channels with different geometries are being fabricated and some have been completed for fluidic testing. The structures for fluidic testing differ from a few microns down to a few hundred nanometers, are covered by thermal bonding with a substrate of the same material and connected to a micropump. During experimentation, the behavior of the fluid-flow through various modified channels will be detected, characterized and compared with the theoretical assumptions [2]. One suitable method of detection is done by using a fluorescence microscope and appropriate beads. This allows imaging the flow and will lead to answers on how fluids behave in these dimensions. These results can lead to a better understanding on how the fluid-flow can be controlled and therefore be used in analysis-systems [3], e.g. for liquid chromatography [4]. Future experiments will include the modification of the channel surfaces and its influence on the boundary effects when different fluids or solutions are used.

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